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NPG Report No. 1263

THE DEVELOPMENT OF INGOT-IRON ROTATING BANDS FOR 3"/70 AA PROJECTILES

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

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Date : 16 April 1954

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U. S. Naval Proving Ground
Dahlgren, Virginia

The Development of Ingot-Iron Rotating Bands for 3"/70 AA Projectiles

by

R. H. Lyddane
and
R. B. Butler
Terminal Ballistics Department

NPG REPORT NO. 1263

Task Assignment No.
NPG-B-3b-225-1-54

16 April 1954

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By direction

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CONTENTS

	Page
Abstract	ii
Foreword	iii
Introduction	1
Procedure and Results	1
Discussion	4
References	4

Appendices:

A. Complete Before and After Firing Data (Tables 1-3)

B. NPG Photographs and Sketches
   - Photographs of Band Types Before Firing (Figures 1-3)
   - Sketches of Band Types (Figures 4-10)
   - Sketch of 3"/70 Nose Plug (Figure 11)
   - Photographs of Recovered Projectiles (Figures 12-30

C. Wire Impression Method of Determining Spin

D. Distribution

ABSTRACT

This report covers work on the development of a swaged-on ingot-iron rotating band design for 3"/70 AA Projectiles. The final design evolved was satisfactory in velocity, gun pressure, and yaw at short range, and not only produced full spin but also showed no perceptible band wear. In addition, it produced negligible body deformation under the band of the fired projectile, and permitted a strong joint between projectile and case. The design is somewhat novel, incorporating a series of high ribs canted to the rear which fold down during run-up and engraving. The band is lubricated with molybdenum disulfide.

Ranging and rapid-fire tests of this design are in progress, and will be the subject of a later report.

FOREWORD

This is the 12th partial report on Projectile Rotating Bands and Components. The work was authorized by BUORD Conf ltr Re3b-RS:mt NP9 Ser 24422 of 15 Aug 1951 (reference (a)) under Task Assignment NPG-Re3b-225-1-52.

The tests upon which this report is based were conducted by:

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Terminal Ballistics Department
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Terminal Ballistics Department

This report was reviewed by:

W. B. ROBERTSON, Commander, USN
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N. A. M. RIFFOLT, Director of Research

INTRODUCTION

Reference (b) reported the first work done on s iron rotating bands for the 3"/70 projectile. Two de. gns of 3"/70 band (Figures 5 and 6), as well as a small-diameter design (Figure 4) not adaptable to service use in the 3"/70 gun, were investigated, and the results indicated that it was possible to fit a 3"/70 projectile with a soft iron (Armco ingot iron) rotating band by using precisely the same method of manufacture as for a copper band, that iron bands caused little if any more barrel strain than copper or copper alloy bands of the same contour, and that projectiles with iron bands of the standard 3"/70 Ex 24 Mod 2 contour, fired from a G-3 gun, showed no evidence of band wear and gave range performance far better than projectiles with gilding-metal bands of the same contour.

This report covers further development of swaged-on ingot-iron band designs for the 3"/70 gun.

PROCEDURE AND RESULTS

All rounds in this program were fired from 3"/70 barrel Type G Mod 3 Serial No. 24493, which had approximately 400 ESR and an origin enlargement of 0.009. This gun has a short run-up, a uniform twist of 1 in 25, rifling with a constant groove depth of 0.035, and is chromium plated (0.006). All rounds were inert-loaded with Epsom salts and fitted with flat dummy nose plugs (Figure 11) to a total weight of 15 pounds. All projectiles were rubber-crimped in the case, except for Type 23 Mod 1, which could not be crimped. All rounds fired were recovered in sawdust and examined. Measurements were made of velocity, pressure, and spin (by the wire impression method, Appendix (C)). In some cases, deformation under the band was obtained from measurements of projectile inside diameter before and after firing.

All the iron bands, with exceptions noted below, were liberally coated before firing with powdered molybdenum disulfide suspended in a plastic paint. It was hoped that this material, which is a well-known high-pressure lubricant, would reduce the friction of the band on the barrel and consequently reduce gun wear.

TYPE 23 MOD 1

The Type 23 Mod 1 band, shown in Figures 1 and 7, was designed to investigate to what extent the length of the iron band could be reduced without detriment to the performance previously observed (reference (b)). This was not an actual design for a 3"/70 band, since it was not possible to crimp it in the case, but only a test device. Only two of these bands were ever fired; the results are shown in Table 1, and photographs of the recovered projectiles in Figures 12 and 13. The results were quite satisfactory, except for an indication of fringing, which pointed out the need for more canneluring.

TYPE 23 MOD 2

During the time in which the Type 23 Mod 1 bands were in process of fabrication, the idea was hit upon of designing a band with several high lips (so as to fit the case properly) with all the lips undercut from the rear. The intention was to produce a design in which the lips on passing through the run-up would be folded down rather than swaged down, with a consequent reduction in band pressure and body deformation of the projectile. A somewhat similar design in gilding metal had been tried much earlier in the 3"/50 Type C (Probert) gun, but this band had failed and was abandoned. Since earlier results had indicated clearly that iron was less susceptible to band wear than gilding metal, it was believed that in the present instance this type of design had a good chance of success. The Type 23 Mod 2 band (Figures 1 and 8) was the first design on this principle. Two rounds were fired along with the Type 23 Mod 1 bands, and the results are shown in Table 1 and Figures 14 and 15. (Two projectiles with the standard Ex 24 Mod 7 gilding-metal band were also fired in the same program

for comparison; see Table 1 and Figures 16 and 17,) The results were highly encouraging. The velocities, pressures, yaws and spins for the projectiles with Type 23 Mod 2 bands were all satisfactory, the recovered bands showed no signs of wear, and the considerable body deformation observed with the standard bands was reduced to negligible proportions (as was also the case for the Type 23 Mod 1 bands; see Table 1).

Five more of the Type 23 Mod 2 bands were made and tested. Three of these were coated with molybdenum disulfide as before, and two had no coating (Figure 2). The results are shown in Table 2 and Figures 18-22. These confirmed the previous results, with the additional observation that the uncoated bands exhibited considerably more temper color than the coated ones. This was taken as evidence that the molybdenum disulfide was providing some effective lubrication, and preventing the bands from reaching as high a surface temperature as they otherwise would. It was therefore decided that molybdenum disulfide coating would be adopted as standard for these bands.

TYPE 23 MOD 3

The Type 23 Mod 3 band was similar to the Type 23 Mod 2, but was shorter and had a somewhat larger effective diameter (Figures 2 and 9). The results for the three rounds fired are given in Table 2 and Figures 23-25. The reduction in length led to no reduction in performance, but the increase in diameter caused an increased amount of temper color, and this band was therefore not considered as acceptable as Type 23 Mod 2.

TYPE 23 MOD 4

The next step was to design the Type 23 Mod 4 band, with the reduced length of the Type 23 Mod 3 and the smaller diameter of the Type 23 Mod 2 band (Figures 3 and 10). The results for the five rounds fired are shown in Table 3 and Figures 26-30. Again the results were satisfactory.

Two of the rounds rubber crimped in cases for this test were pulled apart to determine the debulleting load. Both rounds separated at over 15,000 pounds load. These rounds were then reassembled and fired (Table 3).

DISCUSSION

Fifteen rounds of the basic Type 23 design had now been fired, and each round had shown good performance of the band. Bullet pull strength had been shown to be superior to that obtained with the standard gilding-metal band, and body deformation (and therefore band pressure) was much reduced. In addition, iron bands which did not fail in the gun had been shown (reference (b)) capable of excellent range performance in the G-3 gun, whereas standard gilding-metal bands gave very poor range uniformity when fired for comparison. The remaining important question about the performance of this band was therefore its effect on gun life.

The Naval Proving Ground therefore recommended that the Bureau of Ordnance procure a substantial number of 3"/70 projectiles with the Type 23 Mod 4 band design, together with a new G-3 barrel, for the purpose of conducting ranging tests and, if these should prove successful, eventual rapid-fire tests. This was done, and the ranging and rapid-fire tests, now in progress, will be covered by a subsequent report.

REFERENCES

(a) BUORD Conf ltr Re3b-RS:mt NP9 Ser 24422 of 15 Aug 1951
(b) NPG Report No. 896 of 29 Nov 1951

APPENDIX A

TABLE 1 COMPLETE FIRING AND FIRING DATA

Test of 3"/70 AA Projectiles with Armco Iron Bands in Gun Type G Mod 3 No. 24493

Proj. No.	Firing Order 10/29/51	Type 23 Mod	Powder Charge (lbs.) HKPC-1	Average Pressure (tsi)	Muzzle Velocity (f.s./sec.)	% Nominal Spin	Obturation (in.) I.D. Under High Lip of Rotating Band	Obturation (in.) Projectile Body Length
855	4	1	10.01	20.5	[illegible]	100.0	-.000	-.001
856	5	1	10.01	20.0	3397	100.8	-.001	-.005
857	6	2	10.01	20.9	3420	100.6	-.001	-.006
858	7	2	10.01	20.7	3437	99.6	-.001	-.003
859	10	*	10.01	20.6	3447	99.6	-.054	+.022
860	11	*	10.01	21.4	3412	101.4	-.058	+.018

Type 23 Mod 1 Projectiles according to API Drawing 268 (Figure 7).
Type 23 Mod 2 Projectiles according to API Drawing 269 (Figure 8).
Gun Type G Mod 3 No. 24493 had 387 ESR before this firing.
*Standard Projectiles Type Ex 24 Mod 7.

TABLE 2 — COMPLETE RECORD AND [illegible] FIRING DATA

Test of 3"/70 AA Projectiles with Armco Iron Bands in Gun Type G Mod 3 No. 24493

Proj. No.	Firing Order 11/15/51	Type 23 Mod	Powder Charge (lbs.) HKPG-1	Average Pressure (tsi)	Muzzle Velocity (ft./sec.)	% Nominal Spin
912	2	2	10.01	20.0	3419	99.6
913	3	2	10.01	20.7	3404	99.6
914	6	2*	10.01	20.2	3407	99.6
915	7	2*	10.01	20.7	3409	99.6
916	8	2*	10.01	20.6	3418	99.6
917	9	3*	10.01	18.8	3409	100.3
918	10	3*	10.01	20.4	3431	100.1
919	11	3*	10.01	20.2	3414	100.3

Type 23 Mod 2 Projectiles according to API Drawing 269 (Figure 8).
Type 23 Mod 3 Projectiles according to API Drawing 276 (Figure 9).
Gun Type G Mod 3 No. 24493 had 398 ESR before this firing.
One warming round was fired prior to this test.
*Bands coated with molybdenum disulfide.

TABLE 3

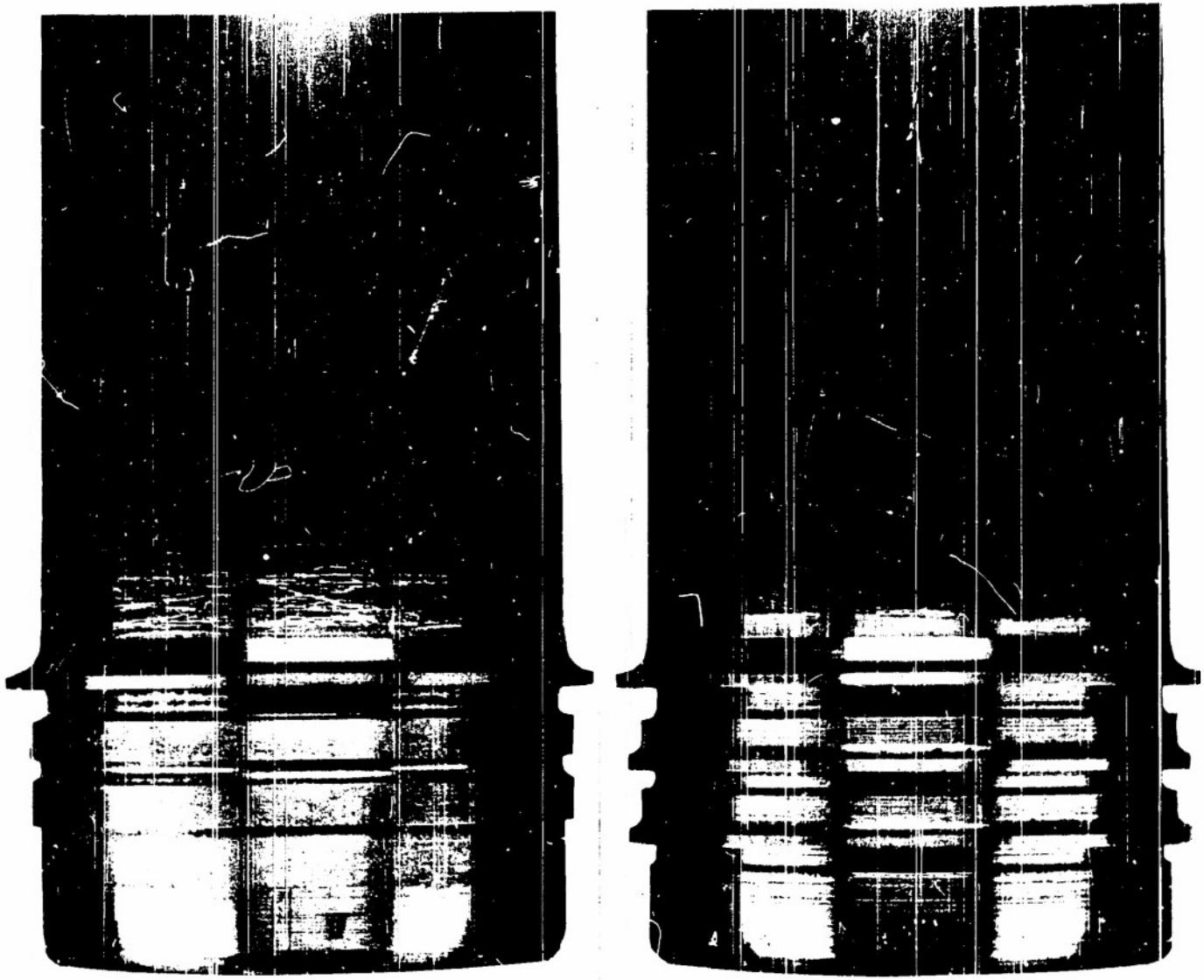
COMPLETE BEFORE AND AFTER FIRING DATA

Test of 3"/70 AA Projectiles with Armco Iron Bands in Gun Type G Mod 3 No. 24493

Proj. No.	Firing Order 12/27/51	Type 23 Mod	Powder Charge (lbs.) HKPC-1	Average Pressure (tsi)	Muzzle Velocity (ft./sec.)	% Nominal Spin	Debulleting Load (lbs.)
943	1	4	9.86	19.5	3374	98.6	15,320
944	2	4	9.86	20.0	3377	99.1	15,760
945	3	4	9.86	20.0	3332	100.1	
946	4	4	9.86	19.6	3383	99.1	
947	5	4	9.86	19.6	3399	99.1	

Type 23 Mod 4 Projectiles according to APL Drawing 281 (Figure 10).
Gun Type G Mod 3 No. 24493 had 409 ESR before this firing.

APPENDIX B



Type 23 Mod 1

Type 23 Mod 2

NP9-65149

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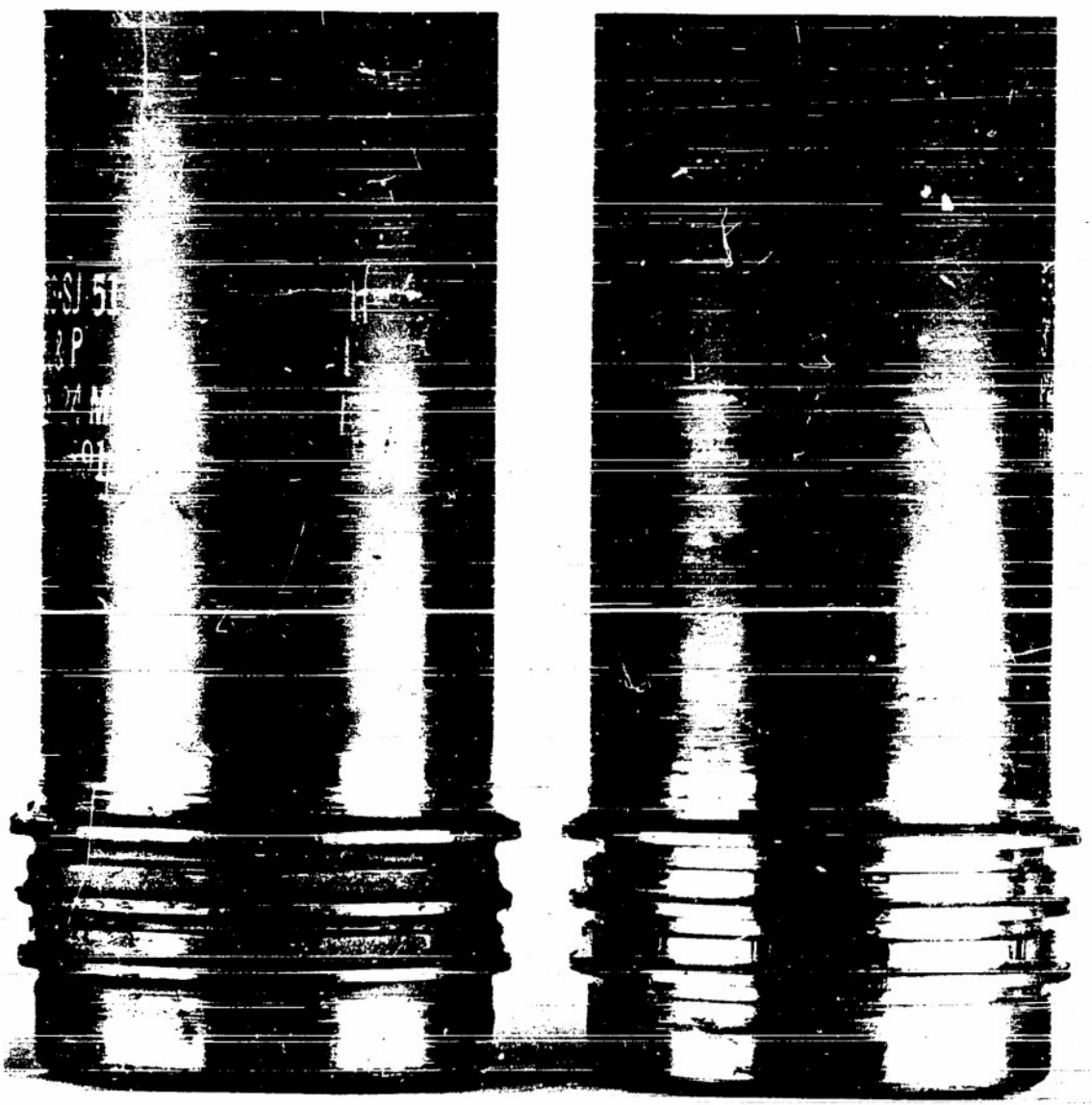
3"/70 AA Projectile Band Designs
Figure 1



Type 23 Mod 3

Type 23 Mod 2

NP9-64809

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3"/70 AA Projectile Band Designs with and without molybdenum disulfide coating.

Figure 2

Type 23 Mod 4

NP9-64810

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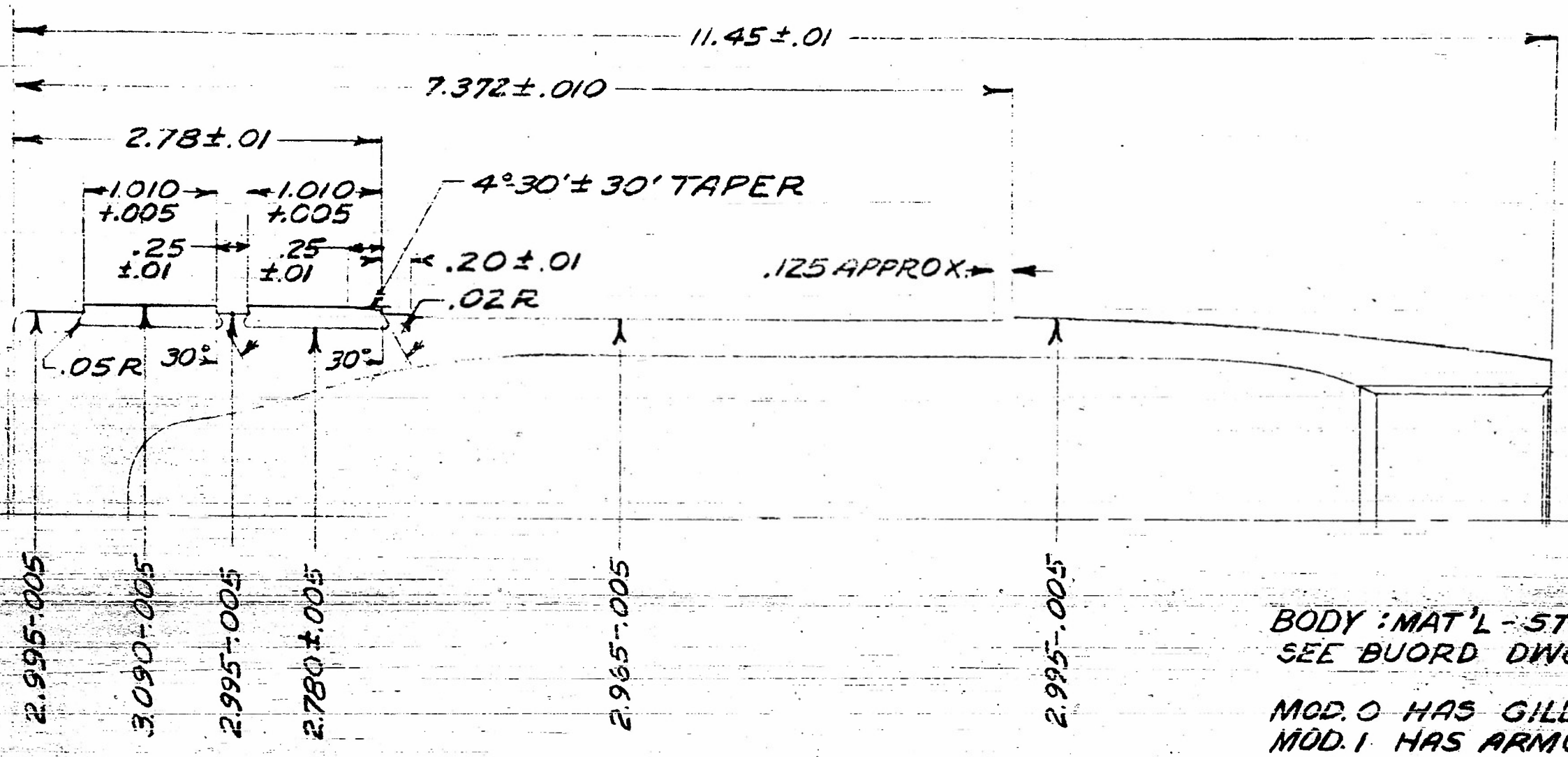
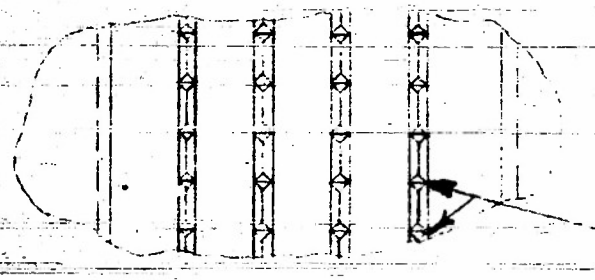
3"/70 AA Projectile Band Design
Figure 3



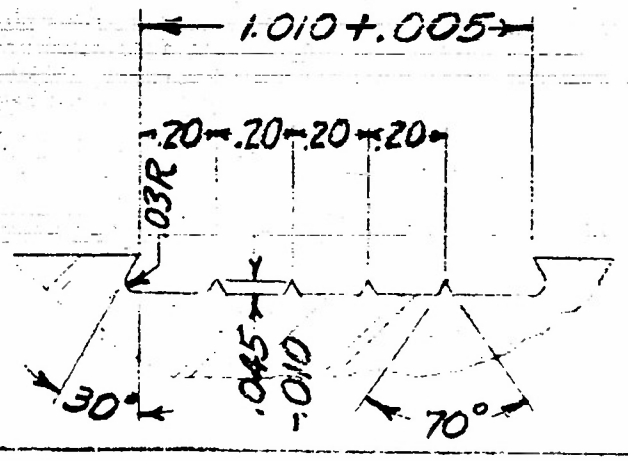
BODY : MAT'L - STEEL
SEE BUORD DWG. NO 239075

MOD. 0 HAS GILDING METAL BANDS
MOD. 1 HAS ARMCO IRON BANDS



BAND SEAT DETAIL

{APPROX. 8 SCORES PER INCH



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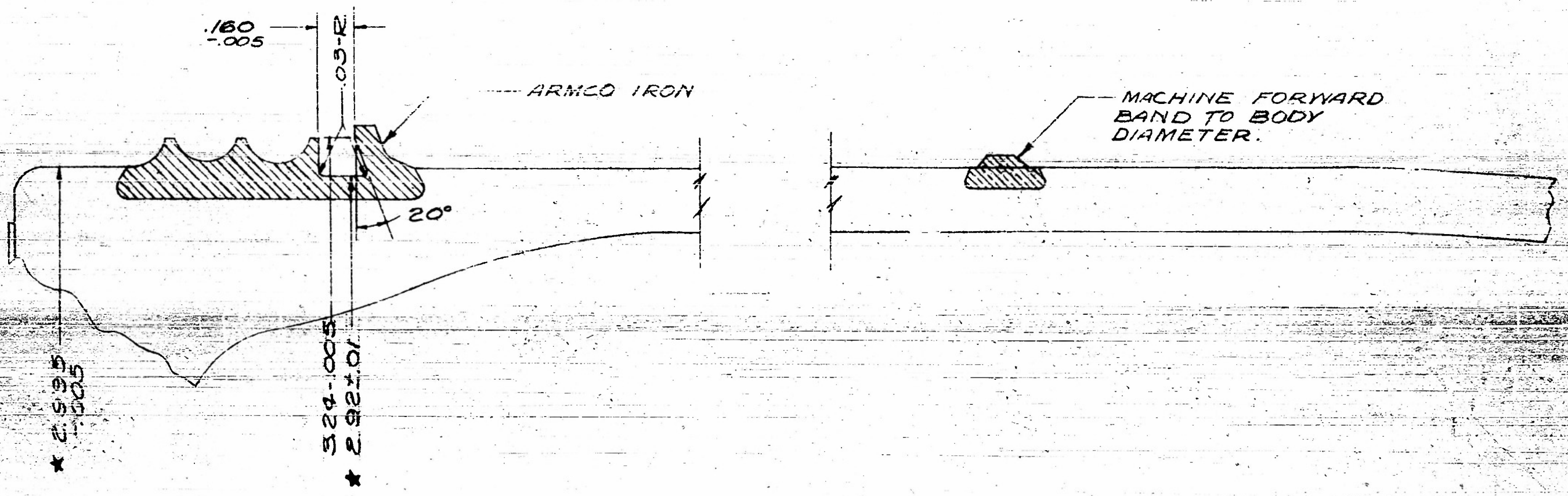
UNLESS OTHERWISE SPECIFIED	APPROVED 19	3"/70 AA PROJECTILE EX 24 MOD 2 MODIFIED TYPE 22 MOD 0 & MOD 1	U. S. NAVAL PROVING GROUND
		1/1 & 1:2 TEST NO. 3203-1.33	DRAWING NO APL-202
	2-27-51 RWD		



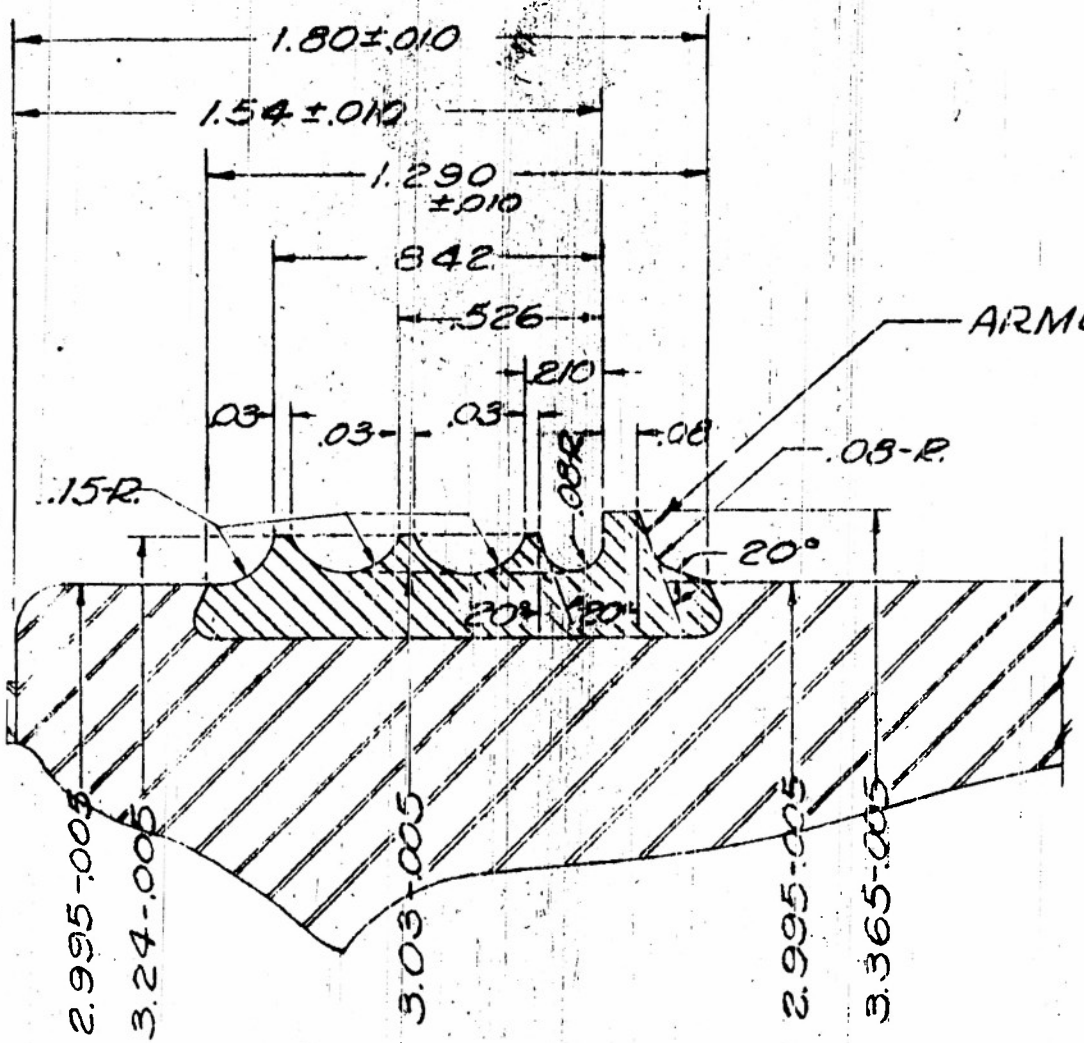
NOTE : STARRED DIAMETERS TO BE CONCENTRIC WITHIN .005"

REF. BUORD SK. NO. 239075 FOR UNMODIFIED BAND AND BODY DIMENSIONS.

CONFIDENTIAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ± DECIMALS ± , ANGLES	APPROVED 19 ORDNANCE OFFICER	3"/70 AA PROJECTILE TYPE EX 24-2 MODIFIED	U.S. NAVAL PROVING GROUND ARMOR AND PROJECTILE LABORATORY DAHLGREN, VIRGINIA
DO NOT SCALE THIS DRAWING			
MATERIAL	CHECKED 3/14/51	SCALE 2:1	TEST NO. T3203-135
	DRAWN 3/14/51		DRAWING NO. APL - 206

FIGURE 25



3"/70 A.A. PROJECTILE TYPE 23 MOD 0
(TYPE EX-24 MOD 2 BAND CONTURE)
SCALE - 2:1

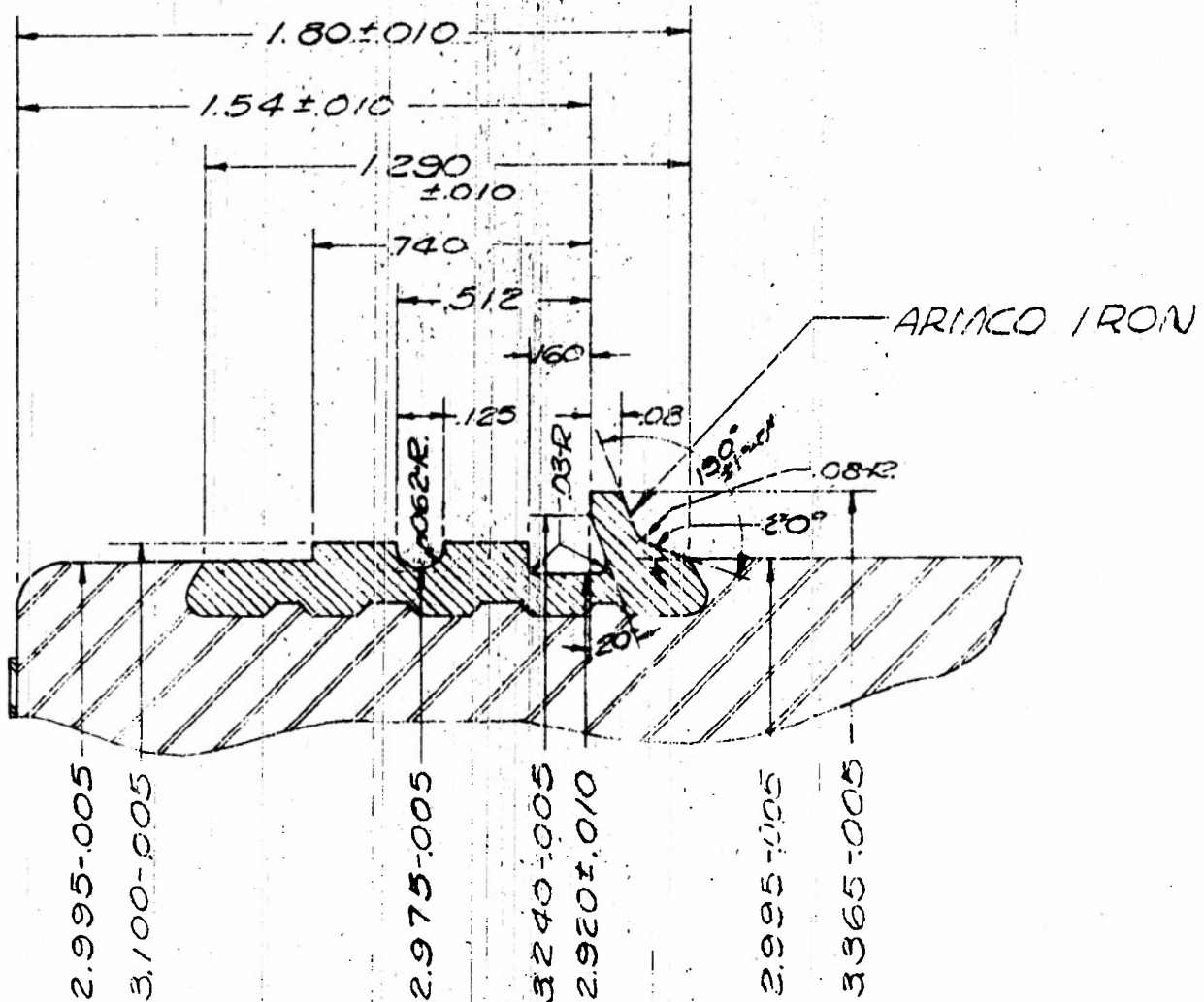
NOTE: MACHINE FORWARD BAND TO BODY DIAMETER.

REF: BUORD SK. NO 249075

3/22/51 W.A.T.
APL-210

FIGURE 6

UNCLASSIFIED



3"/70 A.A. PROJECTILE TYPE 23 MOD 1

SCALE = 2:1

FIGURE 7

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REF: RUCORD SK. NO. 239075

10/17/51 W.A.T.

APL-268

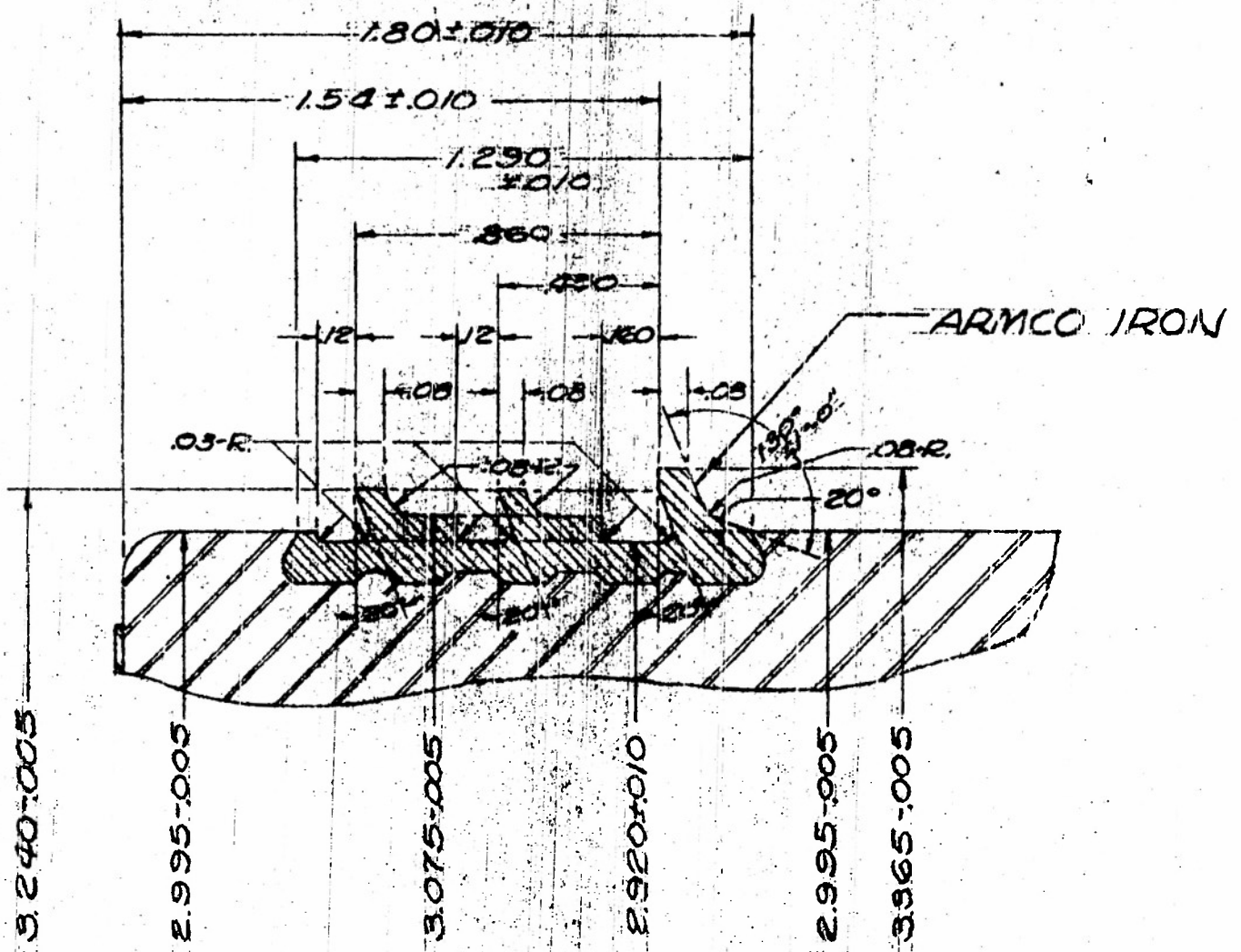


FIGURE 8

3"/70 A.A. PROJECTILE TYPE 23 MOD 2

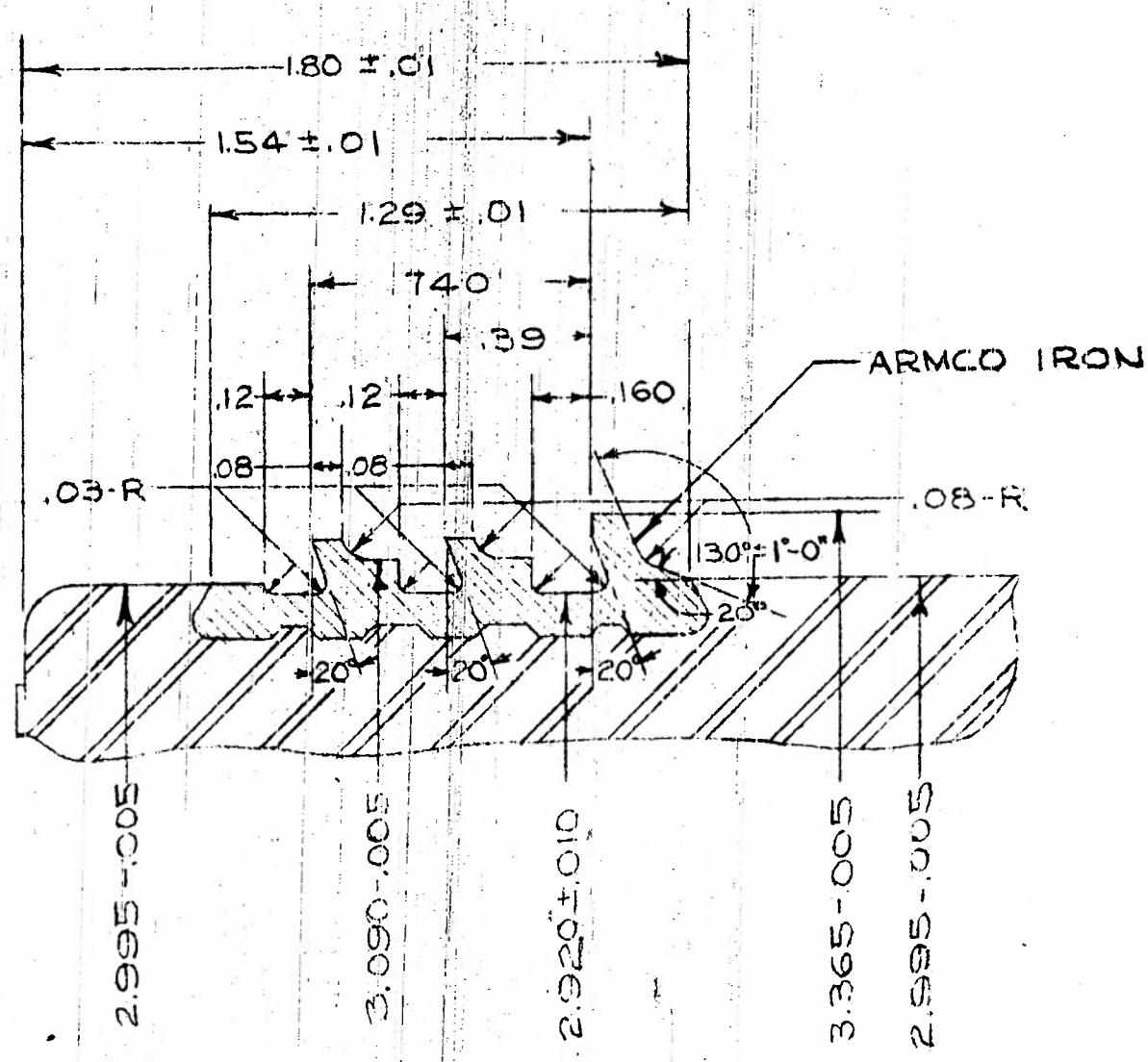
SCALE 2:1

REF: BUORD SK. NO. 239075

10/18/51 W.A.T.

APL-269

CONFIDENTIAL



3"/70 AA PROJECTILE, TYPE 23 MOD 3

FIGURE 9

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REF: BUORD SK. NO. 239075

SCALE: 2:1

11/2/51 adm.

APL - 276

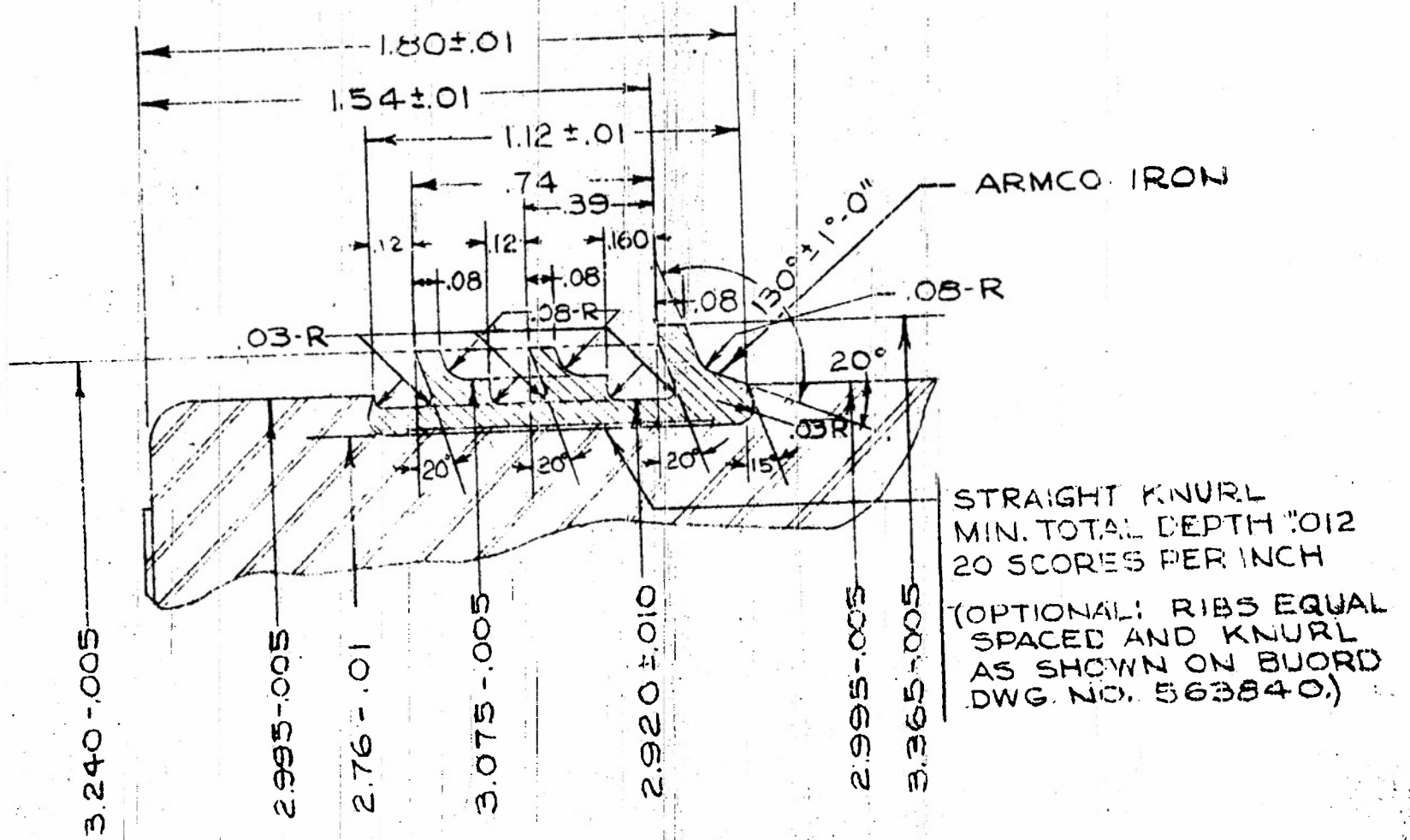


FIGURE 10

3"/70 AA PROJECTILE TYPE 23 MOD 4

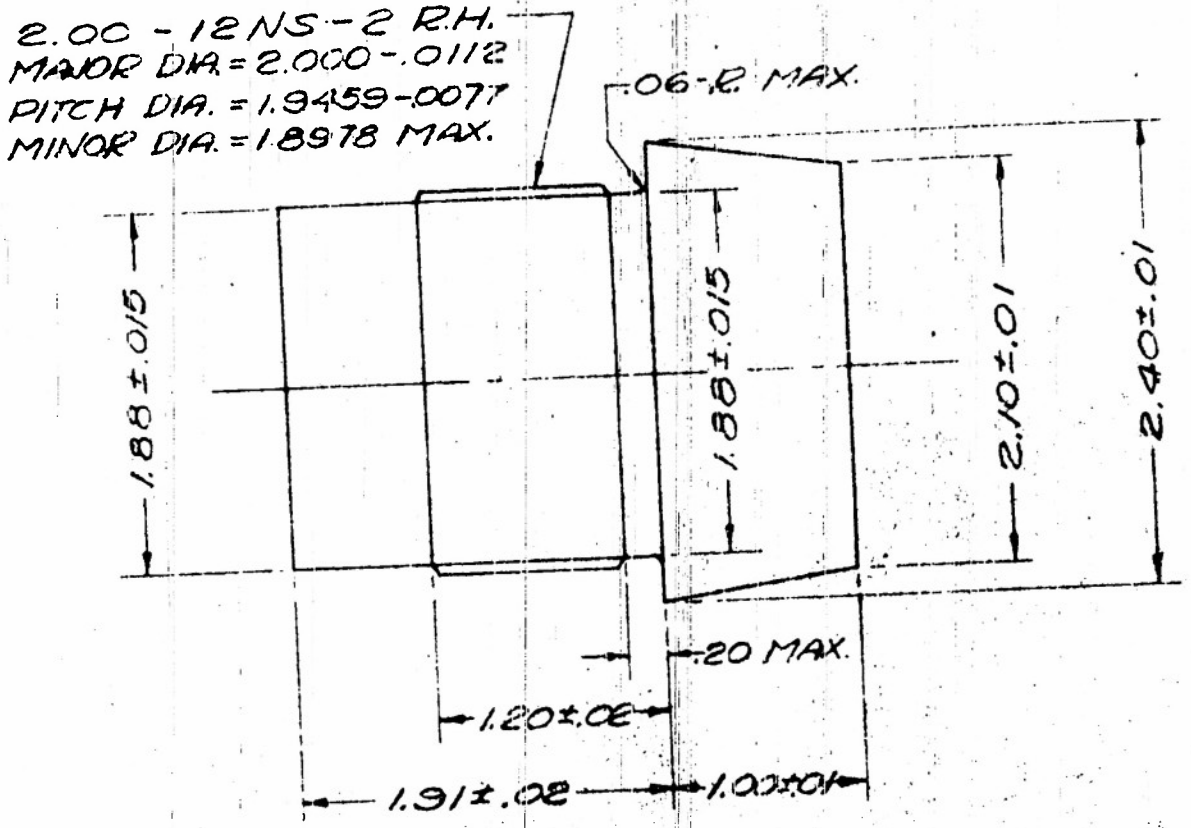
SCALE - 2:1

REF: SEE BUORD DWG. NO. 239075

11/20/51 abm

APL - 251

CONFIDENTIAL



DUMMY NOSE PLUG

MATERIAL: STEEL, FORGED OR ROLLED STOCK.
WEIGHT: 2.68 ± .05 LBS.
NOTE: BREAK SHARP EDGES
REF: SEE BUOED SK. NO. 239269

APL-107
9/27/49 wmf

FIGURE 11

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NP9-64811

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Three views (120° apart) of recovered 3"/70 AA Projectile Type 23 Mod 1 No. 855.
Figure 12

NP9-64812

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Three views (120° apart) of recovered 3"/70 AA Projectile
Type 23 Mod 1 No. 856.
Figure 13

NP9-64813

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Three views (120° apart) of recovered 3"/70 AA Projectile
Type 23 Mod 1 No. 857
Figure 14

NP9-64814 CONFIDENTIAL

Three views (120° apart) of recovered 3"/70 AA Projectile
Type 23 Mod 1 No. 858
Figure 15

NP9-64815

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Three views (120° apart) of recovered 3"/70 AA Projectile
Type EX 24 Mod 7 No. 859.
Figure 16

NP9-64816

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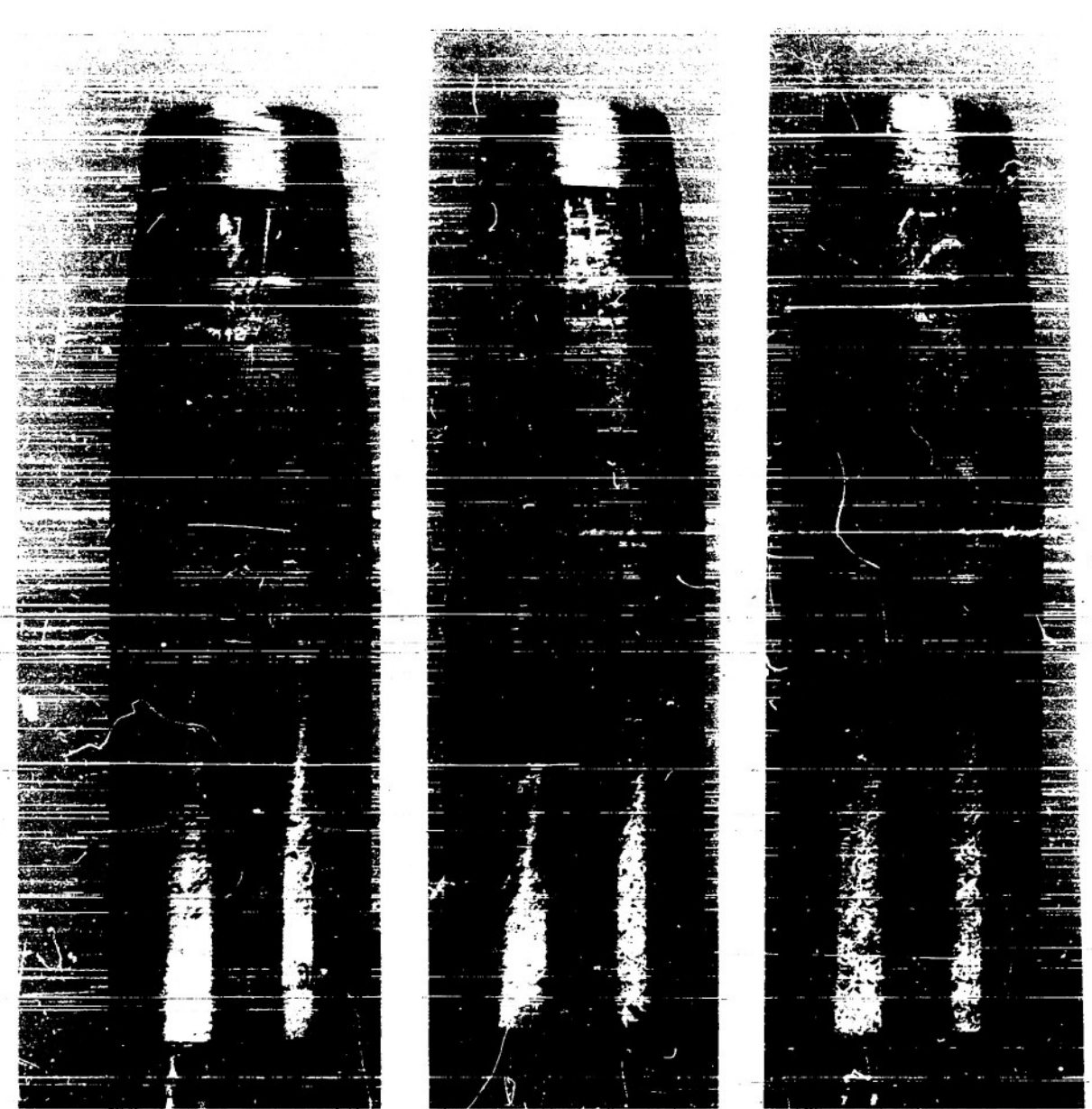
Three views (120° apart) of recovered 3"/70 AA Projectile Type EX 24 Mod 7 No. 860.
Figure 17



NP9-64817

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Three views (120° apart) of recovered 3"/70 AA Projectile Type 23 Mod 2 No. 912.
Figure 18

NP9-64818

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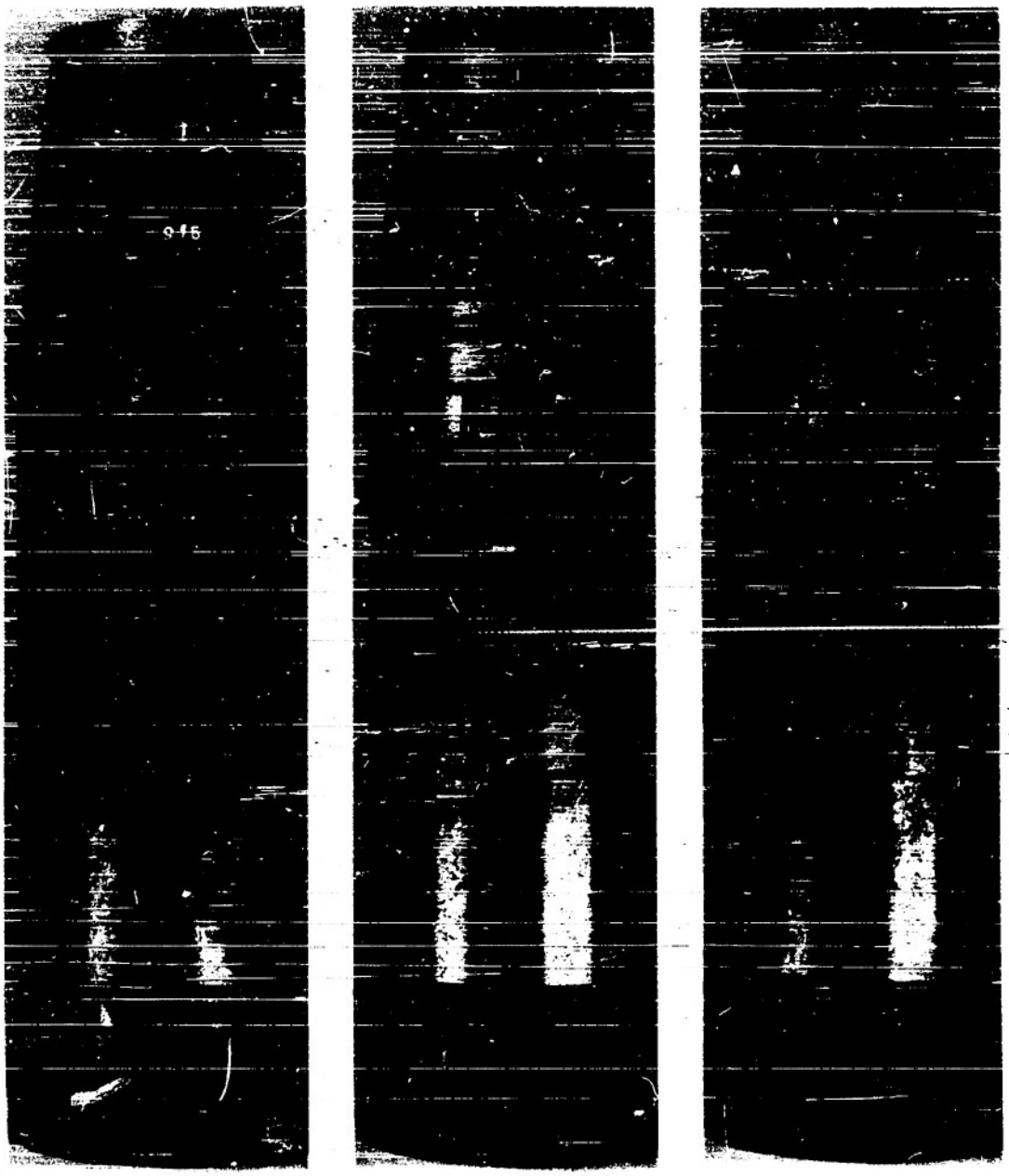
Three views (120° apart) of recovered 3"/70 AA Projectile Type 23 Mod 2 No. 913.
Figure 19

NP9-64819

CONFIDENTIAL

Three views (120° apart) of recovered 3"/70 AA Projectile Type 23 Mod 2 No. 914.
Figure 20



NP9-64820

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Three views (120° apart) of recovered 3"/70 AA Projectile
Type 23 Mod ? No. 915.
Figure 21

NP9-64821

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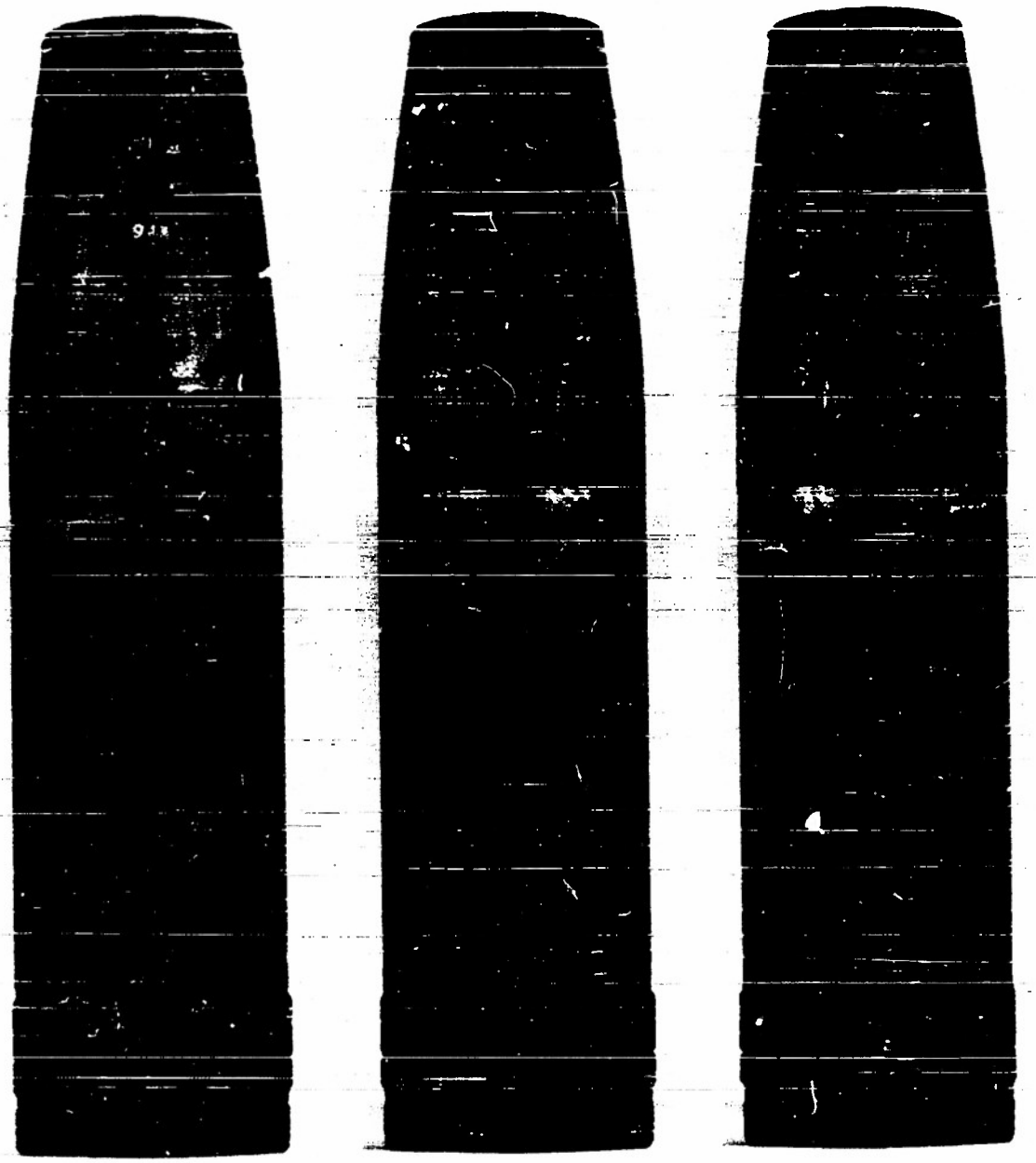
Three views (120° apart) of recovered 3"/70 AA Projectile Tyre 23 Mod 2 No. 916.
Figure 22



NP9-64822

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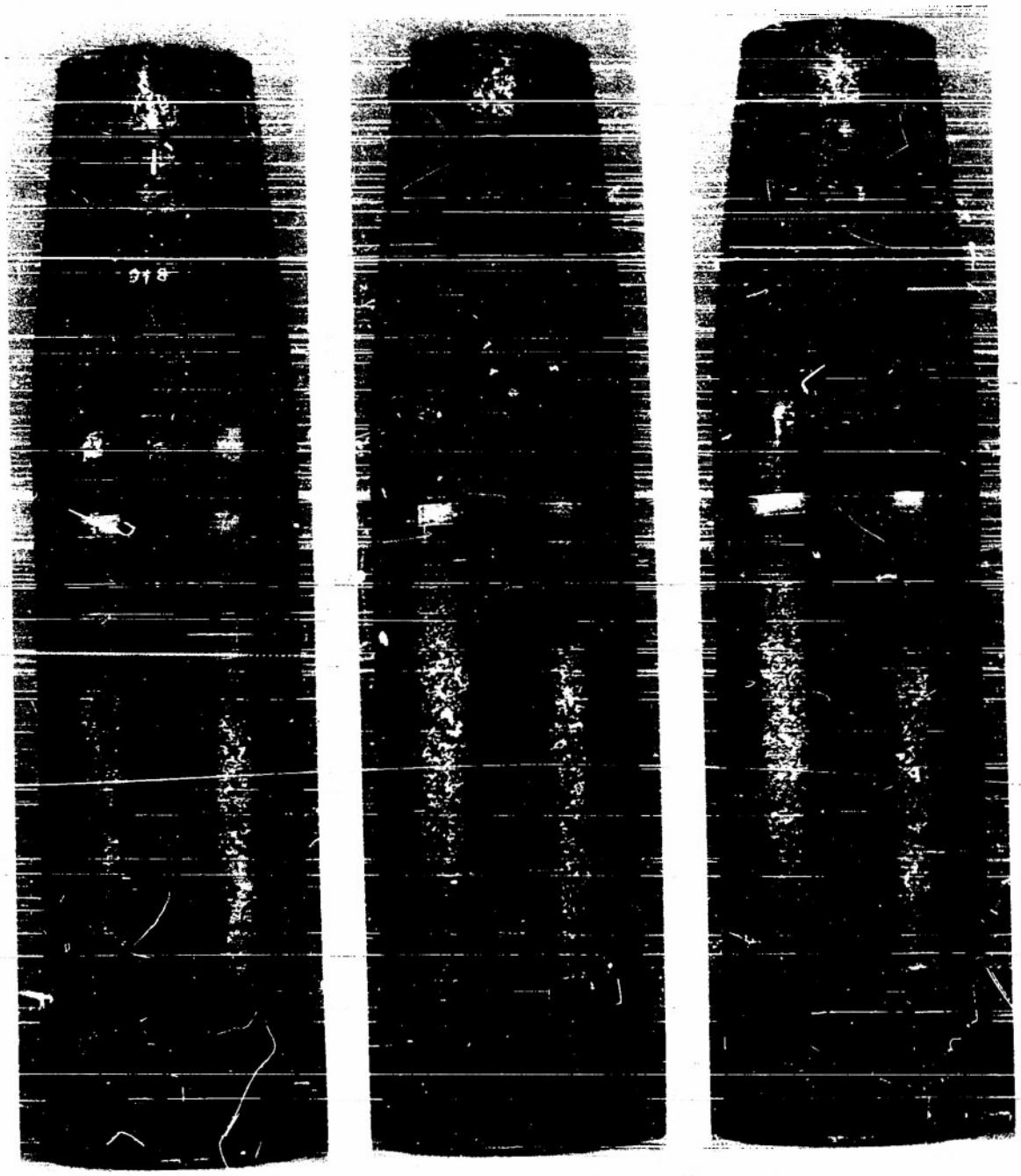
Three views (120° apart) of recovered 3"/70 AA Projectile
Type 23 Mod 3 No. 917.
Figure 23



NP9-64823

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Three views (120° apart) of recovered 3"/70 AA Projectile
Type 23 Mod 3 No. 918.
Figure 24

NP9-6482A

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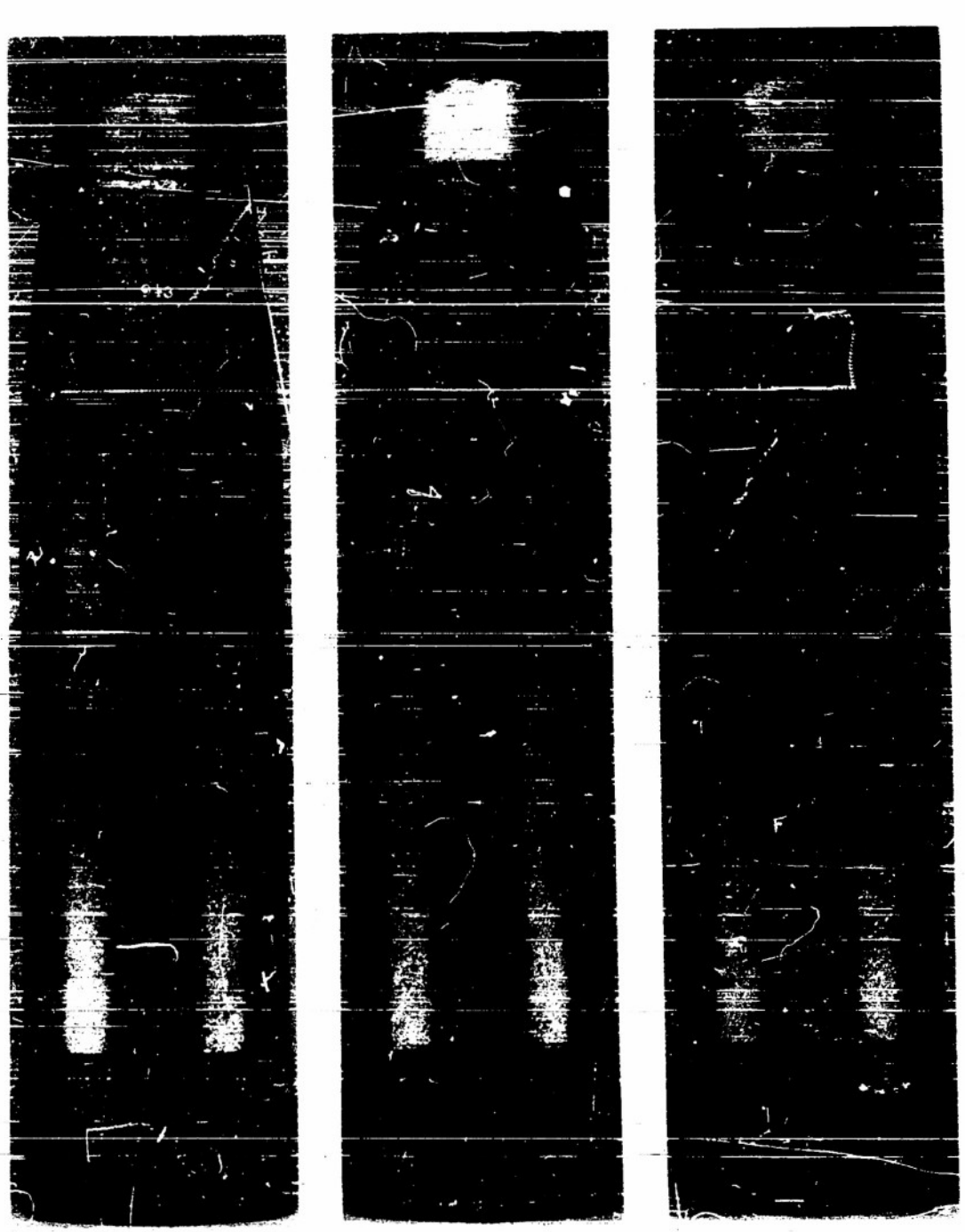
Three views (120° apart) of recovered 3"/70 AA Projectile Type 23 Mod 3 No. 919.
Figure 25



NP9-64825

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Three views (120° apart) of recovered 3"/70 AA Projectile Type 23 Mod 4 No. 943.
Figure 26

NP9-64826

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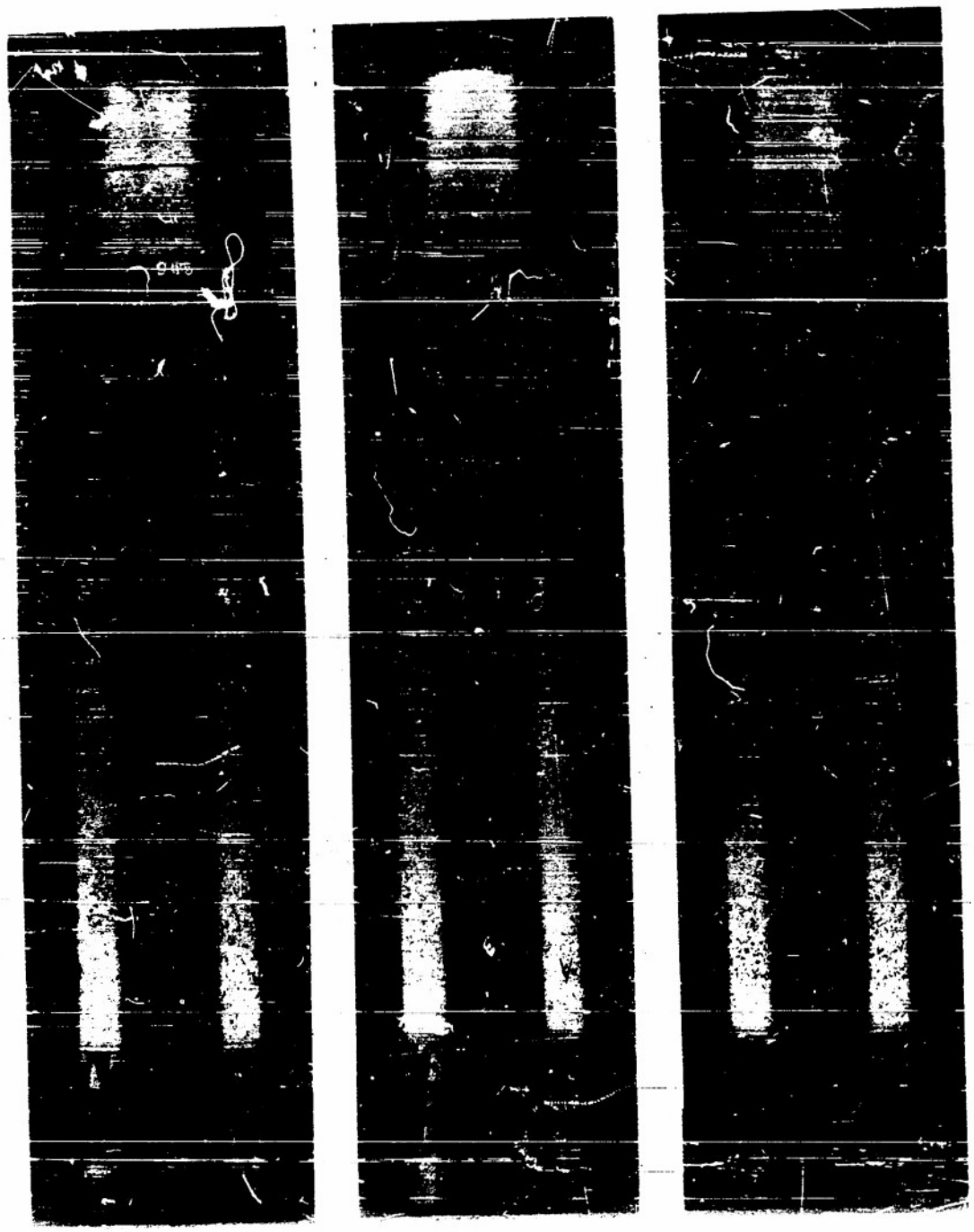
Three views (120° apart) of recovered 3"/70 AA Projectile Type 23 Mod 4 No. 944.
Figure 27



NP9-65133

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Three views (120° apart) of recovered 3"/70 AA Projectile Type 23 Mod 4 No. 945.
Figure 28

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NP9-65134

Three views (120° apart) of recovered 3"/70 AA Projectile Type 23 Mod 4 No. 946.
Figure 29

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NP9-65135

Three views (120° apart) of recovered 3"/70 AA Projectile Type 23 Mod 4 No. 947.
Figure 30 .

APPENDIX C

Wire Impression Method of Determining Spin

Two screens are set up 41⅝ apart, each screen consisting of a metal frame with wood inserts, holding an array of parallel equidistant vertical copper wires. The spacing of the wires is 1/2" for the first screen and 3/4" for the second. The projectile is fitted with a flat-nosed dummy nose plug or the equivalent, so that after passing through the screens it bears two sets of impressions of the wires. The angle between the two sets of impressions is measured and from this measurement the rifling of the gun, the muzzle velocity, and the velocity at the spin screens, is computed the precentage of nominal spin. It is assumed that over the short distances involved the spin retardation is negligible.

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Subject: The Development of Ingot-Iron Rotating Bands for 3"/70 AA Projectiles by R. H. Lyddane and R. B. Butler, Terminal Ballistics Department, U. S. Naval Proving Ground, Dahlgren, Virginia
16 April 1954

ABSTRACT

This report covers work on the development of a swaged-on ingot-iron rotating band design for 3"/70 AA Projectiles. The final design evolved was satisfactory in velocity, gun pressure, and yaw at short range, and not only produced full spin but also showed no perceptible band wear. In addition, it produced negligible body deformation under the band of the fired projectile, and permitted a strong joint between projectile and case. The design is somewhat novel, incorporating a series of high ribs canted to the rear which fold down during run-up and engraving. The band is lubricated with molybdenum disulfide.

Ranging and rapid-fire tests of this design are in progress, and will be the subject of a later report.

Subject: The Development of [illegible]-Iron Rotating Band Design for 3"/70 AA Projectiles, by R. H. [illegible] and R. B. Butler, Terminal Ballistics Section, U. S. Naval Proving Ground, Dahlgren, Virginia [illegible] 1954

ABSTRACT

This report covers work on the development of swaged-on ingot-iron rotating band design for 3"/70 AA projectiles. The final design evolved was satisfactory in velocity, gun pressure, and yaw at short range, and not only produced full spin but also showed no perceptible band wear. In addition, it produced negligible body deformation under the band of the fired projectile, and permitted a strong joint between projectile and case. The design is somewhat novel, incorporating a series of high ribs canted to the rear which fold down during run-up and engraving. The band is lubricated with molybdenum disulfide.

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